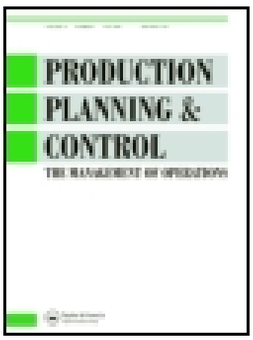

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Making sense of visual management through affordance theory

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ABSTRACT

Visual management is much used within operations management practice, particularly in association with process improvement initiatives in diverse areas such as production and healthcare. The practitioner literature abounds with suggested best practice. However, there is little attempt to theorise about why the design and use of 'visual' devices for such process improvement works in practice. Within this paper we describe a novel theory of operation which highlights the role that material and visual artefacts proposed by visual management practitioners play within particular ways of organising work. We develop an innovative way of employing the theory of affordances to explain how first- and second-order affordances, situated around the visual devices at the heart of visual management, connect three domains of action, which we refer to as articulation, communication and coordination. Our analysis of three cases from healthcare, clothing manufacturing and software production help ground the theorisation discussed.

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Visual management; visual workplace; visual devices; ways of organising; affordance; production operations management; healthcare operations management

> Everything that one can see in an organization sends a message, even a blank wall. (Liff and Posey 2004)

Introduction

The phrase 'visual management' is used in some disciplines to refer very broadly to the application of a visual frame of reference (sometimes referred to as the 'visual turn'), as well as associated visually based research methodologies, to issues of management and organisation (Puyou et al. 2012; Scott and Orlikowski 2012; Bell, Warren, and Schroeder 2014). Within this paper we focus upon the narrower, pragmatic sense of the term adopted within the management of operations, as applied within diverse settings such as manufacturing and healthcare (Galsworth 2005). Here, the term visual management is used to refer to a way of making work actions visible in order to improve the flow of work. Visual management is operationalised in the so-called visual workplace (Galsworth 2005) which involves the use of visual devices of various forms to communicate with 'doers'. Visual devices typically include paper strips and cards, magnetic tokens and whiteboards. Within this paper, we examine a number of visual workplaces in order to understand how the introduction and use of visual devices within these work settings contributes to their effective operation.

The success of visual management is usually linked to process improvement philosophies and particularly that associated with lean operations (Holweg 2007). Besides a few notable exceptions (Parry and Turner 2006; Bateman and Lethbridge 2014; Bateman, Philip, and Warrender 2016), there is a surprising lack of coverage of visual management in the academic literature, both within production and operations management and within the management of healthcare (O'Neill and Jones 2011; O'Brien, Bassham, and Lewis 2014). We speculate that this may be due to a number of reasons. First, the body of knowledge which constitutes visual management has arisen amongst communities of 'lean' practice in over two decades of application. Publications which promulgate visual management are also heavily associated with management consultancy as applied to particular areas of industry and the public sector, which orient their key value proposition in terms of these ideas. Second, we speculate that this lack of coverage within the academic literature may be down to the basis of visual management in what might be referred to as 'folk theory'. In other words, the principles established for visual management by the practitioner community tend to be substantiated in terms of anecdotal cases of apparent good practice, rather than in terms of some foundations established in academic theorising which open up avenues of empirical investigation. Third, visual management is used in contemporary work settings in which there is clear evidence of information behaviour. However, these systems have not been examined in any real detail by cognate fields such as operations management and information systems, perhaps because within such systems there is little or no use of digital computing and communications technology.

In this paper we focus on a class of system which we have both observed *in situ* and identified in the work of other authors, where physical artefacts are used to coordinate routine work. Within such systems information behaviour is accomplished through the use of these physical artefacts operated upon in highly structured environments (Wong and Blandford 2004; Parry and Turner 2006; Mackay 2007; Sehgal 2010). Such physical or tangible artefacts

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include Kanban and T-cards/boards used in production management, paper flight strips in air traffic control, dispatch cards used in ambulance command and control and hospital whiteboards used with magnetic tokens. These systems seem to have endured against the tide of increased computerisation in many operations settings. Bateman and Lethbridge (2014), for instance, describe five different contemporary domains (including a university, a magistrate's court, two general hospitals and a manufacturing plant) where manual whiteboards continue to be used as effective informative artefacts. The theorisation explored in this paper suggests that the visual devices characteristic of these systems offer their users affordances for action which are not easily replicated in digital computer and communication systems currently.

In previous work, we have shown that these systems referred to within the literature have much in common, despite the different contexts in which they operate (Lederman and Johnston 2011). First, they all use physical artefacts such as paper strips, cards or dry-erase/magnetic whiteboards as a means to accomplish information relating to action through shared workplace conventions. Second, the artefacts used gain their informating capacity from the position they take within a structured physical environment, with features of this environment being crucial to the situated use of such material objects. These areas of commonality suggest that if such systems have endured despite the push to computerisation within the various work contexts in which they are employed, there must be lessons to be learnt from their operation. The current paper attempts to explain how visual management is accomplished through these material systems. We base our theorisation around the positioning of visual devices placed at the heart of visual management and aim to explain both the effectiveness and also persistence of these operations practices in numerous different work settings.

To help ground our theorisation we describe three contemporary cases of these material systems. We have chosen these systems particularly because they are representative of certain key examples cited in the visual management literature, which stress the role played by visual devices in the accomplishment of cooperative and often multidisciplinary work (Eppler and Burkhard 2007; Ewenstein and Whyte 2009; Whyte 2013). We begin with consideration of a manual whiteboard used to control aspects of healthcare within an intensive care unit (ICU) of an Australian general hospital. We then consider in more detail a case of routine action coordinated within an Australian clothing production and repair shop through application of a visual device. Both the ICU case and that of the clothing repair shop have a number of elements in common with the use of Kanban (Monden 1983; Sarker and Balan 1998) within production. For this reason, in our last case we consider the use of Kanban within a non-standard area of production – that of software development.

In a recent review of the operations management field Taylor and Taylor (2009) argue that 'there is increasing recognition of the benefit to be gained from exploring contemporary operations practice through alternative lenses and frameworks'. In examining the operations practices of visual management we apply within this paper the alternative lens of the theory of affordances (Gibson 1977, 1979). The folk theory of visual management and the theory of affordances both try to explain how actors use their senses (particularly that of vision) to perceive structures within the environment as cues for action. This leads us to ask, where are the affordances in visual devices? Specifically, we pose the following novel research question in this paper: How can we use the theory of affordances to explain how visual management is accomplished through visual devices?

To answer this question we examine closely the visual devices utilised within our cases and develop a theory of how the affordances of such informative artefacts support action within these systems. We explain how visual devices as material forms serve both to in-form and per-form within such systems.

Within our conclusion, we summarise aspects of our theorisation of visual management and consider a number of prescriptions that fall out of this in terms of how to develop and implement the 'visual' devices proposed by visual management. We also discuss some of the limitations of our analysis and some avenues of research which arise from our work.

Literature review

There is an evident linkage between at least four strands of work related to the notion of visual management. Visual management is particularly associated with the concept of lean production (Parry and Turner 2006; Holweg 2007), but has more recently been utilised within ideas of lean services (Radnor 2010). Lean production is an approach to production management that focuses on cutting waste, whilst ensuring quality. Visual management can also be seen to have its' genesis within the five key principles (sometimes referred to as pillars) of Shingo. These pillars are frequently referred to as the 5Ss after the Japanese words seiri (sorting), seiton (arranging or setting in order), seiso (sweeping or cleaning), seiketsu (standardising or integrating the first three principles into work) and shitsuke (sustaining discipline) (Hirano 1995). Visual management is also particularly implemented in terms of ideas of the visual workplace (Grief 1991) and particularly through systems of visual devices.

The visual workplace employs the idea of using visual devices situated within work settings to communicate with 'doers' – the actual people performing work within these settings (Grief 1991; Hirano 1995; Liff and Posey 2004). Galsworth (1997) defines the visual workplace in terms of the principles of Shingo (Hirano 1995). She refers to the visual workplace as 'a work environment that is self-explaining, self-ordering, self-regulating, and self-improving – where what is supposed to happen does happen, on time, every time, day or night'. Visual workplaces are seen to be instantiated through visual systems, which Galsworth (1997) defines as 'a group of visual devices that are intentionally designed to share information at a glance, without having to say a word'. A visual device is further defined by Galsworth (1997) as 'a mechanism that is intentionally designed to share information vital to the task at hand at a glance – so that what is supposed to happen does happen'. Interestingly, she goes on to define visual information as 'messages communicated through any of the senses: taste, touch, smell, and hearing as well as sight'. This suggests that the visual devices in these workplaces may trigger the perception of opportunities for action by using all the senses, not just the visual. This view is reiterated by the claim, in the production planning literature, that visual aids can be enhanced by audio signals to motivate the workforce in ways that drive productivity (Parry and Turner 2006).

The visual management literature argues that there are a number of types of visual device, defined in terms of whether 'the message it sends is likely to be obeyed' and 'the potential risk or loss if we decide to ignore it' (Galsworth 1997). This distinguishes visual devices in terms of a 'ladder of control' ranging from visual indicators and signals on the one hand to visual controls and guarantees on the other. Visual indicators and visual signals merely suggest certain behaviours to actors but adherence to the messages on the part of such actors conveyed by such devices is optional. In contrast, visual controls and visual guarantees attempt to ensure that adherence to the message is automatically undertaken through the structure of the device itself.

A *visual indicator* is seen to provide or share messages with receiving actors, but it is passive. In other words, whether the receiver of the message complies with the message is optional. Hence, a visual sign placed alongside a particular road and indicating a direction to some designated place necessarily serves to inform a driver of a possible outcome, but the driver does not need to turn his automobile in that direction if his intentions are otherwise.

A *visual signal* also provides a certain message to a receiving actor, but in this case there is an expectation that the receiver takes attention and reacts to the message. The classic example of a visual signal is the traffic light. A red light on this device will indicate to the driver that she should stop. If she fails to stop she is likely to suffer from sanction (such as a police fine) or other deleterious outcomes (such as crashing into crossing traffic). To reinforce the message, visual signals tend to be no longer passive but active – their properties change to reinforce the message. Hence, the light changes colour to reinforce the changing nature of hazard in the road situation. *Visual controls* attempt to impact upon the behaviour of the receiver directly by building the message into the physical environment itself – 'the physical structure of the device sends the message' (Galsworth 1997). The response taken by the receiver of the message is hence no longer limited solely by the message itself. Use of the device constrains potential future action. Hence, speed bumps signal the message to drivers to slow down. However, if a receiver of this particular message does not slow down he is likely to damage his car's suspension. Equally, lines within a car park indicate to users of the car park the proper positioning of parked cars. If such users do not park within a designated parking bay they are likely to be fined by the parking authority.

Other visual devices are based around the notion of visual guarantees. *Visual guarantees* are also known as mistake-proof, fail-safe, or Poka-Yoke devices. 'A visual guarantee is designed to make sure that only the right thing can happen. It prevents us from doing the wrong thing' (Galsworth 1997). Visual guarantees are normally devices designed explicitly to determine certain behaviours unequivocally. For instance, a simple defect-shute of a defined size and down which the machinist must pass every product he produces, ensures that each product is checked in terms of a defined tolerance of width. Another example is the moulding of a tool-holder such that it becomes impossible to position a particular tool in the wrong place and in the wrong orientation for easy access.

Galsworth (2005) has since modified her taxonomy of visual devices by changing some of the terminology and locating 'ownership' of such devices with particular roles in the workplace. *Visual standards* define what is supposed to happen in the work setting and are the responsibility of engineers and supervisors. *Visual displays* indicate the answers to the core questions of where, what, when, who, how many and how) and are the responsibility of supervisors, managers and schedulers. *Visual metrics* provide feedback on performance and are the responsibility of supervisors, managers and executives. *Visual controls* and *visual guarantees* still appear in her taxonomy in much of their original guise.

Although not explicitly engaging with the practices of visual management as described, there is cognate work which has attempted to understand the place of visual artefacts within work. Ewenstein and Whyte, for instance, examine the use of visual objects in design (Ewenstein and Whyte 2009). They suggest that visual objects are either 'frozen', and thus unavailable to be changed, or 'fluid' and thus amenable to be changed as part of cooperative practice. These different types of object can be used to support different types of activities at different stages within some design process. Thus, different visual devices are associated with temporality for Whyte, rather than different roles or activities as suggested by Galsworth.

Similarly, Eppler discusses a range of ways in which visual devices represent organisational knowledge. He discusses what he terms visual metaphors, such as a sketch of a bridge or a ladder which convey 'implicit insights about the represented information through the key characteristics of the metaphor that is employed' (Eppler and Burkhard 2007). Eppler feels that when knowledge is represented visually, through visual metaphors and other visual devices, it helps prevent information overload by compressing large amounts of information and making it accessible (Eppler and Mengis 2004). Styhre (2010) also discusses visual tools from a knowledge sharing perspective and describes a concept which he calls professional vision, where our professional knowledge provides a lens through which we understand visual stimuli. Styhre sees professional communities as sharing beliefs that allow them to ascribe meaning to what they see.

Within the operations management literature, Parry and Turner (2006) describe the operation of a visual process control system which communicates the current state of a process in a similar way to traditional Kanban boards. The board has six columns with new work represented by T-cards being entered on the first column and progressing through the movement of the cards across five other columns (date required; date received; analysis; final check and complete). The T-cards migrate across the board with value being added as the T-card is placed within each column. Team members identify which work package they are working on by putting a coloured marker on each T-card. The board is used as a communicative device and a place for meetings and progress reviews and a source of information not just about task progress but about resource use and the status of production overall.

From such work it is evident that visual devices are particularly associated with the attempt to translate organisational expectations into directly observable, concrete practices. Such expectations may be formulated by management, as suggested by the visual controls and guarantees of Galsworth. However, within production management philosophies such as Shingo, these devices are frequently designed or co-created by work-groups with the express purpose of continuously improving production processes. Such organisational expectations are frequently framed within the visual management literature as 'discipline'

– influencing, directing, limiting or guaranteeing people's behaviours through visual devices (Galsworth 1997). Visual devices such as performance boards or checklists therefore are an attempt to convey expectations of valued behaviour while also implying that such behaviour is monitored to ensure adherence.

Visual devices are also used to tackle what Galsworth (1997) refers to as *information deficits*. An information deficit occurs when information does not get shared rapidly, accurately and completely amongst the workforce as soon as it becomes available. Galsworth (1997) believes that such deficits come in two forms: location deficits and specification deficits. Location deficits result from not knowing where things are. Specification deficits result from workers not knowing what is required, when it is required, how to do something and how much or how many of something is required.

Visual management has continued to have influence on the practice of operations and production management (Liff and Posey 2004; Galsworth 2005; Parry and Turner 2006), particularly as it concerns lean operations (Bateman and Lethbridge 2014; Bateman, Philip, and Warrender 2016). There is a recent trend to adapt many of the principles of visual management to service as well as manufacturing settings. For instance, manual whiteboards as visual devices for enabling coordinated work have been used within healthcare, within higher education and within legal settings (Bateman and Lethbridge 2014).

The authors we have discussed, such as Eppler, Parry and Whyte, try to understand how visual devices operate to share organisational knowledge. However, they do not fully explain how these visual devices act to coordinate patterns of action performed by multiple actors and frequently operating across multiple domains of action. In Parry and Turner's (2006) study, for instance, we see how T-cards placed upon their board are not just an isolated set of visual indicators and controls but are part of a broader, multidimensional system of production management. However, there is little theorisation of how the visual device provides value to the wider system of operation.

Dickes et al. provide some insight in this area. They ask how actors make meaning in social situations and how actors combine the context of a social situation with the semiotic resources situated in the broader environment (Dicks et al. 2011). Hurdley and Dicks state further that

> Insufficient attention is often paid to the extent to which this emplaced and materialized meaning-making also mobilizes qualities that are displaced from our immediate sensory perceptions, in that they inhere in signifiers (objects and materials) embroiled in wider organizations of cultural value and meaning. Meanings are made in situ through the full spectrum of sensory phenomena with which actors engage – from what can be seen with the eye to what can be heard, touched, smelled, tasted – but also reverberate within webs of signifiers beyond the immediacy of unfolding interactions. (Hurdley and Dicks 2011)

Hurdley and Dick's idea of a 'web of signifiers' connotes a concept previously used within psychology, which may provide some insight into the operation of coordinated work using visual devices – the notion of *affordance*. If we study many of the examples provided by the literature, we see that what is common is the notion that the visual objects and artefacts under study all communicate some course of action to users, whether by constraining action through use of a visual control or by creating a signal or indicator for an actor to respond to. They do this through multiple senses and often across a web of different indicators, visual or social. This positioning of visual objects in relation to sensation and action has much in common with the theory of affordances.

This theory also makes us think further about the operation of visual devices or objects. Authors such as Galsworth and Eppler focus on the individual objects that make up visual management. They focus on different representational forms such as tables, heuristic sketches, diagrams, metaphors and maps (Eppler and Burkhard 2007) and see these objects as controlling behaviour, or signalling a type of behaviour (Galsworth 2005). The theory of affordances, however, suggests that the accomplishment of visual management is achieved through the operation of whole systems, not just isolated objects.

In the next section we discuss the theory of affordances and establish foundation for a new framework for understanding how visual management systems operate. Within our conceptualisation of visual management systems, we shall show how affordances operate across three distinct domains of action.

The affordance of material and visual artefacts

The concept of affordance was originally developed in Gibson's work, *The theory of affordances* (Gibson 1977) and was later elaborated upon in his book, *The ecological approach to visual perception* (Gibson 1979). Since its inception, the idea of affordances has been applied in numerous disciplines beyond psychology such as sociology (Bloomfield, Latham, and Vurdubakis 2014), human-computer interaction (Norman 1999), computer supported cooperative work (Schmidt and Simone 1996), information systems (Leonardi 2011) and organisation science (Zammuto et al. 2007; Van Dijk et al. 2011). In the course of this application the concept of affordance 'typically "travels light", leaving behind much of the conceptual apparatus of Gibsonian psychology …' (Bloomfield, Latham, and Vurdubakis 2014). Interestingly, the concept of affordance appears little used within the areas of production and operations management and never referred to within the visual management literature itself.

The concept of affordance has been much applied in thinking through notions of appropriate design in relation to artefacts such as computer interfaces (Norman 1999). However, the concept itself seems particularly well suited to helping explain actions in relation to physical or material artefacts used for informative purposes, such as those proposed within the literature of visual management. Within this section we first provide an account of the theory of affordances based firmly within Gibsonian psychology. In a further section we then demonstrate the need to adapt and somewhat extend this theorisation to adequately explain how visual management works in practice.

Gibson (1977, 1979) defines an affordance as 'what the environment provides or furnishes'. The idea is that actors directly perceive the opportunity for action within the structure of the environment. Hence, a horizontal surface of sufficient size in relation to some actor affords support – it is stand-on-able. Or alternatively a surface at more or less knee height in relation to the actor affords sitting on – as an affordance it is sit-able. This idea is related to Gibson's view that meaning is not a cognitive act. Meaning is already present and available to actors in the environment. In directly perceiving aspects of this environment actors inherently pick up cues to action through their sensory systems.

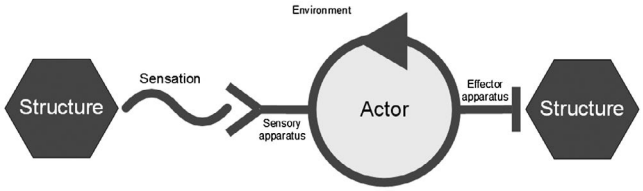

Figure 1. The elements of an affordance.

This idea resonates with Galsworth's view that many senses are involved in picking up clues for action from the environment and that the environment itself can effect a 'discipline' over action (Galsworth 1997). Similarly, within semiotics certain signs are proposed that can be sensed and processed subconsciously in support of action (Nöth 1990).

However, for certain structures within the physical environment to afford action the actor must have certain capabilities or effectivities for performing action. Effectivities are 'properties of animals that allow them to make use of affordances' (Shaw and Turvey 1982). In this view, affordances require the actor to have particular abilities which allow her to make use of a particular structure in the environment to effect action. As such, effectivities clearly relate to the embodied apparatus of a particular actor – on the one hand, to an organism's sensory apparatus and on the other to an organism's effector apparatus. The sensory apparatus consists of all the sense organs making up the organism while the effector apparatus consists of all the organs through which the organism can transform aspects of the environment. Hence, for instance, a rock of a particular size and shape is only sit-able because we as humans have stereo vision allowing us to sense physical objects as three-dimensional. But we are also bi-pedal organisms and as such can effect the act of sitting.

To recap, therefore, the original theory of affordances relies on a number of key presuppositions:

- That the physical environment is structured – that the properties of structures are non-arbitrary, meaning that such properties are invariant across situations and hence are observer-independent.
- Physical structures within the environment are perceived directly by actors without any intermediate, conscious, cognitive processing.
- Physical structures constrain or enable actors through the opportunities they provide for action.
- Whether a physical structure affords action by a particular actor depends upon the effectivities of the actor – its' sensory and effector apparatus.In summary, *an affordance is an opportunity for action made possible both by the effectivities of the actor and by structures in the environment*. The critical elements underlying the theory of affordances (structures, actors and effectivities) are illustrated in Figure 1.

In the next section we discuss three cases of visual management that we use to help ground our theory of their operation.

Three cases of visual management

In this section we examine three case studies and consider them through the lens of the visual management literature and the theory of affordances. The first two cases, an ICU bed allocation system, and a clothing shop repair job management system were both analysed *in situ* through observations and interviews with key workers over a period of months. A qualitative analysis was done of all data using Nvivo software to established themes for grounded analysis. The first case has been previously discussed in the literature with a full description of the case methodology available (Lederman and Johnston 2011). The second case study is presented for the first time in this work and uses the same qualitative methodology as the first case (Lederman and Johnston 2011). After some initial unpacking of the first two cases we introduce the third case as a tool for further exploration of our theory. This third case identifies a similar type of system to the first two cases and seeks to reinterpret a detailed published case description of Scrumban (Ladas 2009) as a source of data.

In the following subsections we initially introduce the important elements of the first two cases and attempt to explain them through the lens of affordance theory. We then develop an extended theorisation of affordances, applicable to the visual devices of visual management, and which we apply in a reinterpretation of the case of Scrumban as a way of organising software development.

Case one: organising bed allocation on an ICU unit

The first of our published studies involved an investigation of the practices surrounding a manual whiteboard used for the allocation of beds within the ICU of an Australian General hospital. The whiteboard was placed in the middle of the nurses station in a 24 bed ICU ward and was a focal point for discussions about bed allocations by a multidisciplinary community of doctors, nurses and allied health care workers. The physical state of the whiteboard as well as cues provided by the actual state of the hospital ward constrained action choice for those using the board. An illustration of the whiteboard in use within this case is provided in Figure 2. The whiteboard was used in conjunction with 24 magnetic patient name cards which were moved throughout the day around the board and a series of coloured tokens and magnets, denoting such things, for example, as 'definite discharged' (green magnet) 'palliating' (yellow magnet), or 'same name as another patient' (blue sticker). The observed state of this whiteboard as well as the observed state of the ICU itself were used by nursing staff to make situated choices about bed allocation. For instance, the nurse manager always made a call at 9 am each morning to operating theatres to determine likely demand for ICU beds. This call was always taken in front of the whiteboard and from where all the beds on the ward could be observed. Hence, within cases such as the ICU nurses do not appear to decide what to do in terms of bed allocation by examining the whiteboard and rationally and consciously assessing choices. Instead, a mere glance at the whiteboard is sufficient to enable the nurse to make immediate, routine choices about bed allocation, often constrained by physical features of the environment which make only one choice of action possible.

Case 2: organising the repair of clothing

Our second case provides a detailed unpacking of another system utilised in organising operations within a small clothing

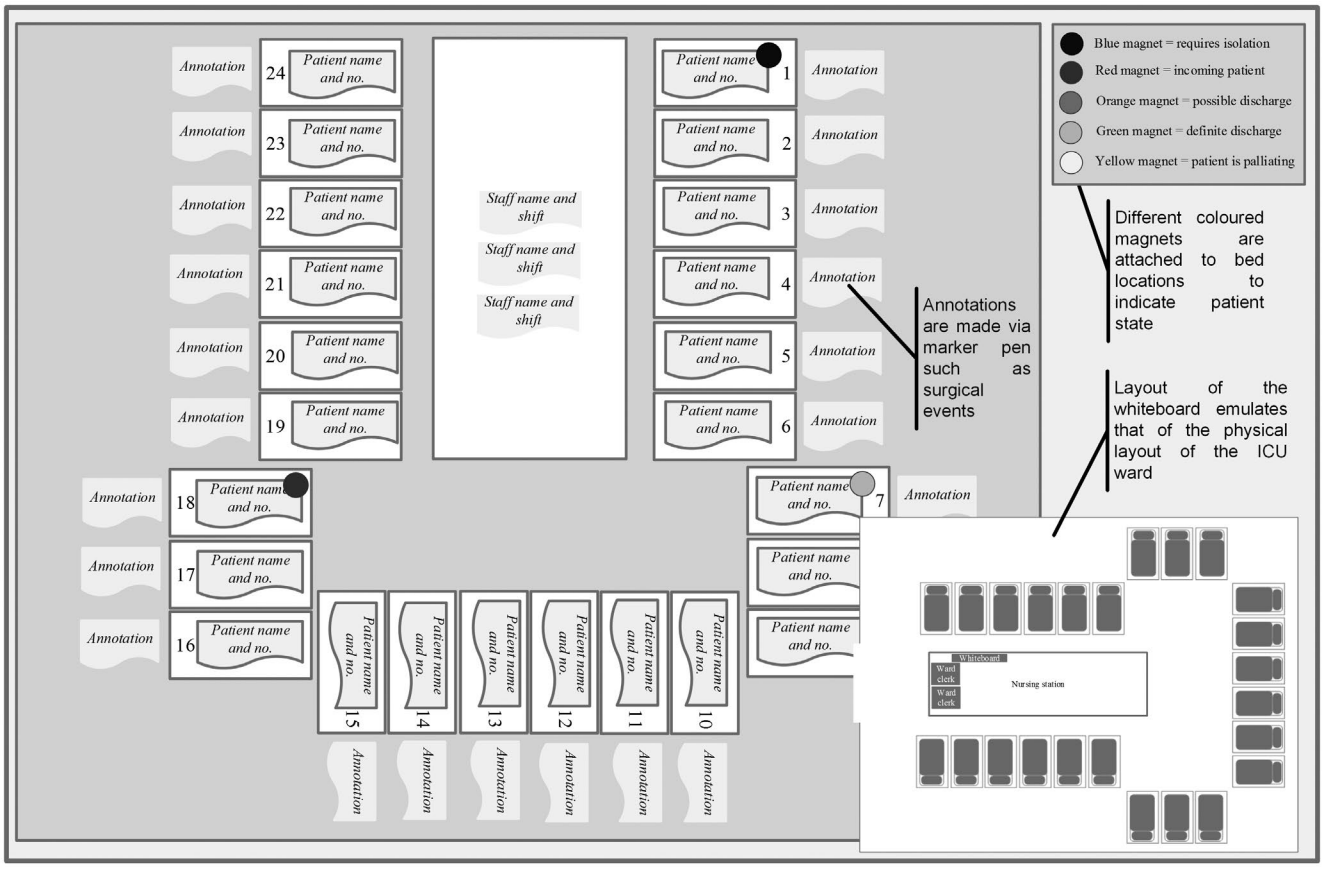

Figure 2. A manual whiteboard used in intensive care.

production and repair shop. The shop performs repairs to clothing as well as engaging in a limited amount of new clothing production. Three actors within this setting undertake a number of routine tasks on a daily basis including taking jobs from customers, selecting jobs to work upon, completing jobs and matching customers to completed jobs. This particular case is useful for our purposes in unpacking difficulties with the concept of affordances because it is far simpler in nature than the ICU case referred to in the previous section.

The routine work here takes place within a long rectangular space within a shop positioned on a busy high street. At the front of the shop are two machine areas with sewing machines. Positioned further into the shop area along the right wall is a reception desk. Alongside this desk is placed a cardholder which hangs on the wall and is used for the scheduling of work. Behind this are two changing cubicles. On the left hand side of the room hang racks of clothing. This rack extends to the back of the shop. There is also clothing on hangers placed upon a hook outside one of the changing rooms. These hangers are for jobs that are to be completed the same day they are brought in.

The main artefact used within this visual management system is the cardholder (see Figure 3). This consists of four rows of horizontal clamps fixed to the wall and into which are placed job cards. A particular job card consists of a rectangular piece of cardboard on which are recorded data about the client such as name, address and telephone number. All job cards also have a coloured sticker placed in the corner indicating the month the order was taken. The first three rows of the cardholder hold cards assigned to the six days of the working week. The last row holds cards relating to jobs that have been completed and are waiting for collection upon the card rack.

Making sense of the cases in terms of affordance theory

The visual management literature would analyse both the ICU and clothing repair shop cases as follows: In the ICU ward, the whiteboard itself acts as a visual device which controls and directs what activities can be performed on the ward. Visual signals (Galsworth 1997) or signs (Nöth 1990) such as a magnet placed on a picture of a bed cubicle tell the admitting nurse that no new patient can be placed in this bed. A filled in space on the board acts as a metaphor for a full bed (Eppler and Burkhard 2007). Visual controls, such as the colour associated with particular magnetic tokens, tell nurses to act (or not to act). For example, a yellow magnet indicates a patient is palliating, so certain actions are not required. Visual guarantees are enforced by the physical workplace itself. Hence, only one patient can be put in a particular bed on the ward and particular bed locations within the ICU are always used for patients with particular medical conditions.

The visual management of the ward promotes the carrying out of activity in a routine manner where actors can directly perceive the visual device within its' wider physical environment, such as the hospital ward, and act routinely with little deliberation by using visual cues for action.

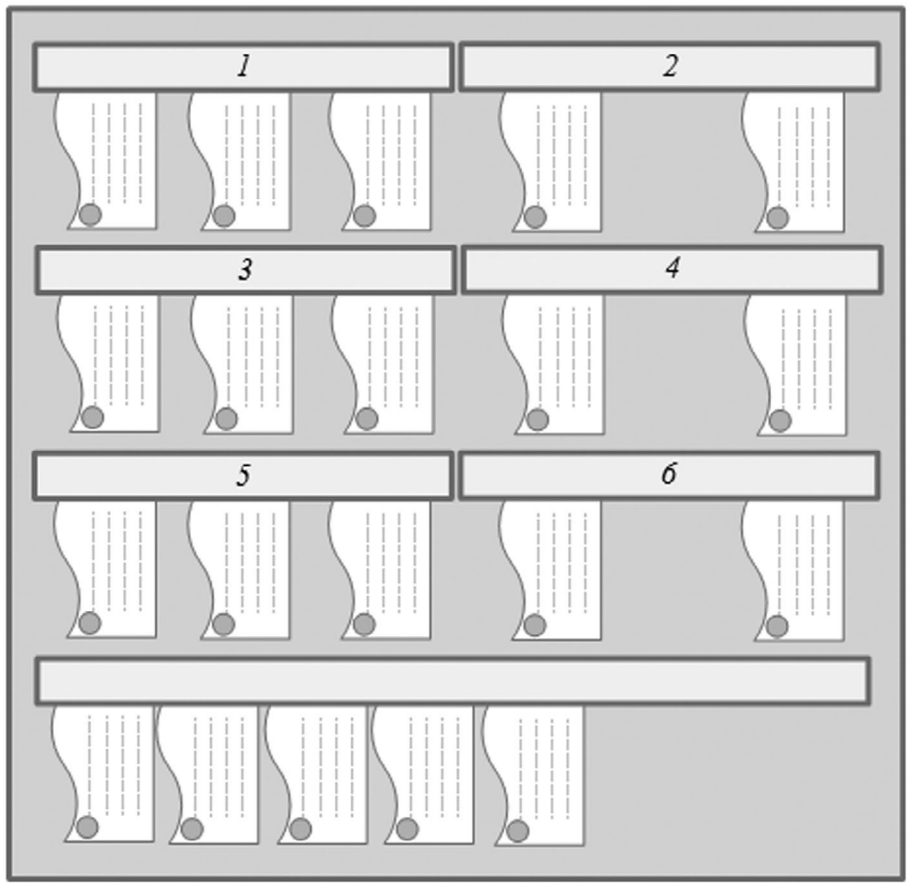

Figure 3. Card holder in the clothing repair case.

However, the idea that users of these systems directly perceive visual cues is problematic if we consider the earlier discussion we provided of Gibson's view of affordances. The key presuppositions of Gibson's original notion of an affordance make it difficult to apply this idea to the use of artefacts such as the cardholder and its associated job cards. This is because Gibson's notion of an affordance relies upon direct perception of cues provided by physical structures, which stimulates action in relation to such physical structures.

But there is a paradox surrounding the affordances of the tangible artefacts manipulated in such systems. Clearly a physical artefact such as job card affords actors certain actions. However, the affordances of such artefacts are typically used as cues or triggers to further action in another context or domain – what we call the co-ordination domain, where the work is coordinated. For instance, in the case of the clothing shop, selecting a job card from the cardholder triggers work on a defined garment (not on the directly perceived job card itself). This linkage is difficult to account for within the classic notion of an affordance.

Schmidt and Simone (1996) propose the idea of a second-order affordance to overcome the conceptual limitations of affordances in situations such as those described above. The idea relies upon the notion of two linked domains or physical environments. One domain, termed the articulation domain, is the domain in which artefacts such as job cards are manipulated. A related domain, termed the work domain, is the domain in which work is performed. Hence, arranging magnetic tokens on a hospital whiteboard is undertaken within the articulation domain and constitutes articulation work. Such manipulation acts in the capacity of coordination mechanisms in the field of work. The movement of magnetic tokens, for instance, serves to coordinate the arrangement of patients on the hospital ward.

Therefore, the idea of second-order affordances is proposed to try to accommodate the situation where manipulation of a structure S_1 in domain A affords manipulation of a structure S_2 in domain B. Domain A is the *articulation domain* and domain B is the *work or coordination domain*. Hence, the manipulation of a magnetic token on a whiteboard is a first-order affordance in the articulation domain. This action triggers a second-order affordance in the related work domain, such as moving a patient to a particular bed on the ward. As such, the manipulation of a structure in the articulation domain acts as a coordination mechanism which serves to control the flow of activity in the work domain.

But for this theorisation to have any efficacy we must explain how the relationship between a first-order and a second-order affordance actually works. As we understand it this relationship relies on the notion of convention. Actors within the setting learn and utilise rules about the relationships between actions associated with the manipulation of structures in the articulation domain and structures of action in the coordination domain. This must involve proposing a third domain of action which couples or connects the articulation domain with the work domain. First- and second-order affordances we believe are coupled through communicative conventions established by multiple actors within

situations of routine work. Hence, the articulation domain within which first-order affordances operate is connected to the coordination domain in which second-order affordances operate through an intervening communication domain.

In terms of our clothing repair case, within the articulation domain workers are manipulating artefacts such as job cards and the cardholder. The articulation domain is therefore best expressed as that domain in which actors manipulate physical objects as data structures. For instance, in the case of the clothing shop, a worker presumably inspects the cardholder a number of times throughout the working day. They can be observed to continuously pick job cards from the cardholder and return job cards back to the holder.

Within the clothing shop, the coordination domain involves the performance of actors in instrumental, coordinated work. Within this domain, workers are continually collecting garments from the hanger, making alterations to garments and returning garments to the appropriate hanger.

To properly explain the effective coordination of action amongst multiple actors in cases such as the clothing shop we must theorise an intervening layer of action which involves the communication of intentions between multiple actors. In previous work (Beynon-Davies 2015) we have found it useful to regard manipulation of physical objects as data structures in the articulation domain as serving as various forms of 'speech act' (Searle 1970) in the communication domain. In other words, each manipulation of a visual object is likely to trigger one or more informative actions, which fundamentally involve communicative conventions relating manipulations in the articulation domain with manipulations in the work domain.

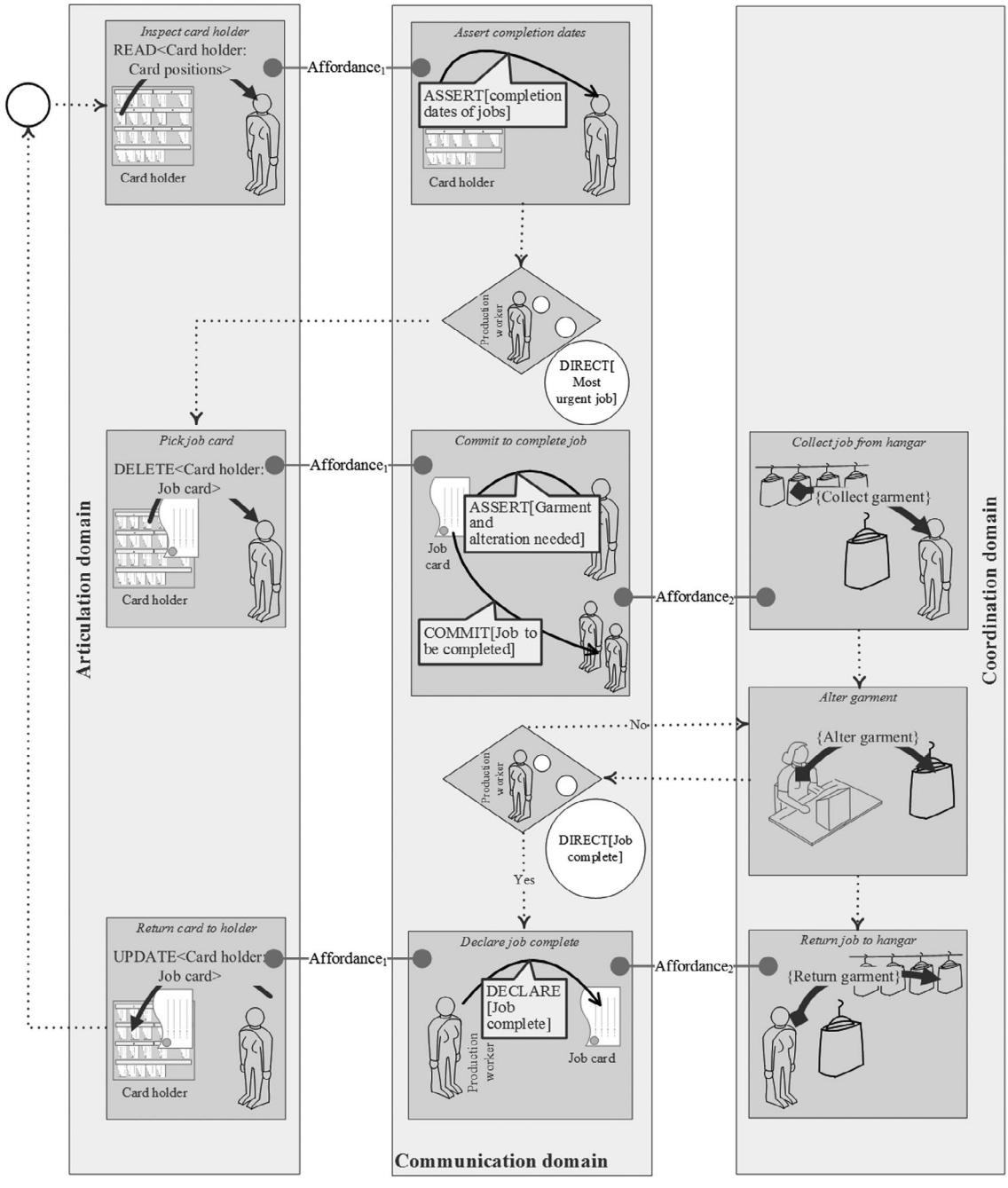

Figure 4. Operation of the clothing repair case.

This means that we propose that it is useful to think about situations such as the ICU and the clothing shop as a *way of organising* – a way of accomplishing mutual action between multiple actors. Such ways of organising may be usefully unpacked in terms of three domains of action: an articulation domain and a coordination domain coupled together through a domain of communication.

Figure 4 provides a simplified visualisation of the workings of the way of organising experienced in the clothing shop. It separates this environment into the three domains of action referred to in the previous section – an articulation domain, a communication domain and a coordination domain. Within the articulation domain, actors act upon artefacts such as the job card and the cardholder. The coordination domain corresponds to the domain in which work is performed such as picking garments, repairing garments and returning completed garments to hangers. Interposing between these two domains lie the communication domain where the manipulation of a particular artefact such as a job card signals intention from one actor to another.

Hence, the positioning of job cards in the cardholder *asserts* to particular actors the likely completion dates of jobs. This serves to help workers decide on the scheduling of their own work. The act of picking a job card from the cardholder by a particular actor is likely to serve as a *commitment*; signalling to other workers that this worker intends to complete the job by the completion date. Returning a job card to the cardholder by an actor will presumably *declare* a job as completed.

We take it as a general principle that these three layers of action can be analysed separately but in practice are coupled. The idea of coupling is taken from the work of Dourish (Dourish 2004), where he defines it as 'the degree of coordination of two elements, and how that coordination is maintained'. We further propose that this idea of coupling, at least as it applies to tangible information systems, appears to relate to the idea of first- and second-order affordances, as we have described them. The coupling between the articulation and communication domains we think must refer to the traditional notion of first-order affordances. Actors use the manipulation of data structures within the articulation domain with the intention of affording communication between themselves and others. The state of the articulation domain at any one time may serve to communicate collective intentions, which, in turn, affords the coordination of work within the coordination domain. This is the idea of a second-order affordance.

To take just one example from the illustration in Figure 4 to stress the relationship between coupling and affordances: a production worker selects an item of work by picking a job card from the cardholder. The job card itself asserts to this production worker the garment to be selected and the type of work to be conducted upon it. But the removal of this job card also signals a commitment by this worker to other workers in the production shop that she will complete the job in the time required. This act of selecting a job card therefore not only affords the action of doing the correct work on the appropriate garment it also affords the coordination of work amongst the multiple workers of the clothing shop.

Case 3: Scrumban

It is interesting that the way of organising bed allocation and the way of organising clothing repair described in this paper were not designed by any management consultant and did not adopt any explicit principles of visual management. Instead, they were created by the participating actors themselves through a process of 'bricolage' (Ciborra 2002). Nevertheless, through such involved design, many of the principles promoted by the communities of practice associated with visual management have emerged in the ways in which organising is accomplished and happens in such settings.

The systems exploited within these particular ways of organising bear a marked similarity to the articulation of Kanban cards and to Parry et al's earlier mentioned T-Card system, as an exemplar from the field of production and manufacturing used for the coordination of material flow through production units. For our third case we further illustrate the idea of first- and second-order affordances operating across three domains of action by using a derivative of Kanban. What is particularly interesting about the case of Kanban is that even though certain enterprise IT systems have incorporated Kanban signalling into their workflow processes (da Silva et al. 2014), many proponents of Kanban argue against application of IT in this area and propose instead the value of applying low-technology solutions such as Kanban cards (Anderson 2010). Such a so-called physical Kanban system is useful in setting the context for the articulation of similar artefacts in relation to another contemporary example of a tangible information system – the use of a task board in the management of software production.

Within the last decade or so a number of changes to practices within the domain of software production have occurred, which are frequently denoted by the term agile computing or sometimes agile development. Practitioners from within this approach to software production have started to adopt and adapt a number of practices from lean production management (Hines, Holweg, and Rich 2004; Staats, Brunner, and Upton 2011). Interestingly, in doing so, they have promoted the use of low-fidelity, or 'agile' technologies which have much synergy with physical Kanban.

Within the current paper, for our third case, we focus upon an agile development technique known as Scrum. The term *scrum* is taken from the game of rugby and refers to a formation used to restart the game after some event has occurred, such as an infringement. Scrum works with the definition and prioritisation of key tasks to be done within the development of a particular piece of software, planning sessions for each task, execution of tasks in timeboxes and constant review of progress in daily meetings. Within the last few years a number of practices from so-called 'lean' production have been adapted to the problems of agile software development (Poppendick and Cusumano, 2012). One of the most successful adaptions has been the melding of Kanban 'pull-production' philosophy with the agile method Scrum. Ladas (2009) collectively refers to this fusion as Scrumban.

Within his essays on Scrumban, Ladas refers to a number of possible ways of adapting Kanban principles to agile software development (Ladas 2009). Within this section we focus upon the utilisation of a key material artefact adapted from pull-production and used to help Scrum work – the Scrumban task board. Ladas describes a simple scenario of applying lean principles to the Scrum approach based around use of this task board, which has many possible configurations, one of which is illustrated in Figure 5. Physically, the task board consists of a grid into which various task cards are placed. Scrum assumes that a particular software

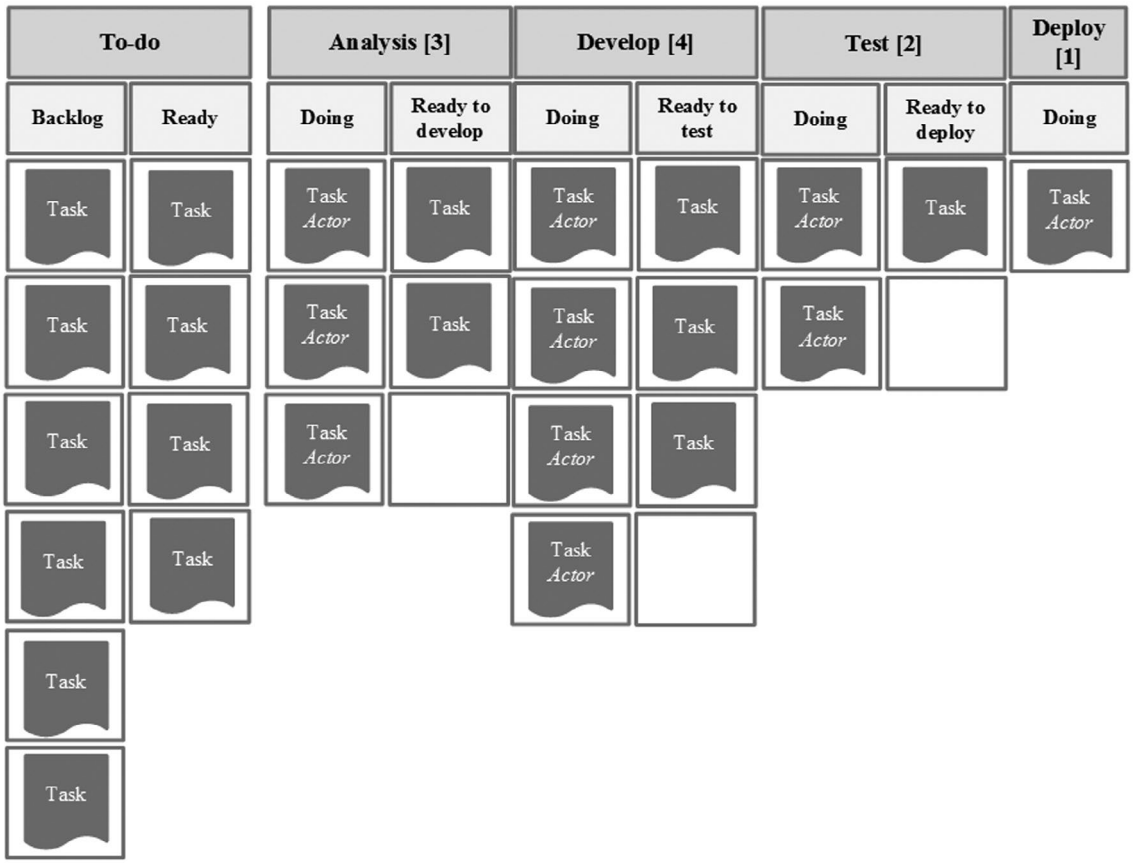

Figure 5. A Scrumban task board.

product can be broken down into a number of distinct features which can be implemented in a defined unit of time known as a *timebox*. The main problem of the project manager (often referred to as the Scrum manager or Scrum master) is to effectively allocate various tasks performed in relation to a particular software feature amongst a limited set of defined members of the software development team. It is with this coordination problem in mind that task or feature cards are used.

Vertically, the task board is divided into 5 major parts of an iterative software development process. Each part comprises a list of one or more cards, up to a maximum defined limit for each list. Feature or task cards are moved across these sections of the board to represent the allocation of work. The *To-do* section is used to represent the tasks or features that have to be built. When a new feature is first determined it is added to the backlog list. When it becomes available for development it is added to the to-do ready list. The four other sections of the flow board represent to the Scrum team when a feature is being analysed, developed, tested or deployed. A feature can be being done or ready to move into the next stage of this process. When a task is being done, a named Scrumban actor is indicated upon the card. When a task is in a ready state, no actor is indicated as allocated to the feature/task.

The case of Scrumban bears much similarity to cases 1 and 2 and the many material systems described in the introduction. It involves the use of material artefacts in support of routine and repetitive action on the part of participating actors – the members of the Scrumban team. Ladas (2009) particularly suggests the use of physical artefacts rather than the use of digital computing and communications technology to support such routine work. He stresses the importance of simple technology for visual control of production activity because it is easy to manage and easy to change. He also suggests that 'huddling around a computer monitor, even a very large one, is in no way a substitute for the tactile and social interactivity that accompanies manipulating a large task board' (Ladas, 2009). It is clear that within the case of Scrumban actors are able to utilise tacit knowledge of the use of such artefacts as well as the way in which the work environment is structured as cues to appropriate and immediate action.

Within the articulation domain for Scrumban workers are manipulating artefacts such as Scrumban cards and the Scrumban task board. For instance, in the case of Scrumban, both the Scrumban manager and Scrumban workers within the team will inspect the task board at least twice during the working day: probably at the start of the working day during a *startup* session and at the end of the working day during a *washup* session. At such times particular actors will be seen to pick a Scrumban card from one list upon the task board and place this card in another list upon the task board. This articulation act of moving a card is visualised as deleting an item from one list on the task board and creating a list item on the next list on the task board.

But there are two other aspects of articulation. Scrumban managers are the actors responsible for moving a task card from a ready list to a doing list. This transition involves them also in annotating the particular task card with the name of an assigned

worker within the team. Scrumban workers are responsible for moving a card on which they personally are named from a doing list to a ready list. In doing this they remove their name from the task card.

The task board is continuously visible to all Scrumban workers within the development environment. This means that particular Scrumban workers are likely to be continuously reading the ongoing state of the entire software production effort. This accounts for what Ladas refers to as the tactile and social interactivity of a large task board.

The work domain for Scrumban involves the performance of actors in coordinated, instrumental work. Within this domain the required features of a particular software product are initially determined in collaboration with clients. Such features are then iteratively produced in a loop in which some workers are continually analysing, some are developing, some are testing and others are deploying particular features of some software product, in unison.

The third domain of action within this system is the Scrumban communication domain. As an example of action within this domain, a Scrumban manager *declares* a change of state of a particular feature in two ways to the work group. First, she will move a Scrumban card from a ready list to a doing list. Second, she will annotate the card with an identifier for a particular Scrumban worker. When the nominated worker has completed the task assigned he will remove his identifier and place the card in a ready list. This piece of articulation serves to *declare* the completion of a particular task to the group.

Theorising visual management

We speculate that the theorisation proposed in previous sections has potential for better explaining how certain production philosophies such as the visual factory (Grief 1991), visual management (Galsworth 1997) and visual control (Liff and Posey 2004) provide value to the management of operations. Such theorisation is important for explaining not only how these systems work but why they are effective and enduring in particular situations of work. A well-formed theory of this nature should also suggest ways in which visual management can be better performed in practice.

We believe that the operation of a large number of the examples cited in the practitioner literature on visual management, particularly as they pertain to the use of visual devices within wider visual systems, can be explained by employing the theory of affordances. Our previous work suggests that such systems have four features in common. These features relate the effectivities (sensory and effector capacities) of actors with structures in the physical environment of the work situation through the notion of communicative conventions.

The first feature is that these systems involve use of material and typically highly visual (tangible) artefacts for informative purposes. The second feature is that the physical manipulation of such artefacts in relation to each other is important to informing actors within group work. The third feature is that the overall state of the physical environment in which such manipulation takes place is also important to informing actors. The fourth feature is that the manipulation of physical and visual artefacts is important to supporting situated choice.

Feature 1: the use of material artefacts

There is sufficient evidence within the cases discussed to show that the very physicality of the artefacts we have discussed is particularly important to the informative potential of these ways of organising. Hence, in terms of effectivities, it is critical that such artefacts are easily sensed by the sensory apparatus of particular actors and easily manipulated by the effector apparatus of particular actors. For instance, in terms of an artefact such as a job card it is not only important that this artefact affords actors the potential to write upon it, it is also important that it affords positionability. A job card can clearly be positioned, usually in relation to other such artefacts upon the cardholder. This means that the physical arrangement of artefacts in space as well as the movement of artefacts through space is important to their informating capacity (Zuboff 1985). Informating is a concept coined by Zuboff to refer to the way in which the manipulation of artefacts '… produces a voice that symbolically renders events, objects and processes so that they become visible, shareable and knowable …'. Moving a magnetic disc on an ICU whiteboard is a significant and informating act as is the positioning of a job card upon a cardholder or a feature card on the task board.

We feel it is incorrect to refer to the key artefacts proposed within the tradition of visual management purely as visual devices because the message conveyed by such devices is frequently sent over other sensory channels besides vision. This is acknowledged in the typically very general definition used within the literature for 'visual management' provided in the first section of the paper. For example, a speed bump may be seen but is also experienced as a kinaesthetic sensation. Hence, as a vocabulary, it is also somewhat cumbersome to refer to the visual workplace or visual management, when the theory of affordances indicates that all senses may be involved in perceiving structure in the environment.

Feature 2: How artefacts inform across time

The second feature is that the physical manipulation of such artefacts in relation to each other is important to informing different actors across time. This means that it is important to separate out the act of articulating or form-ing the artefact from its use for doing something. Within the context of situations in which we are interested it is important to separate out (at least for the purposes of analysis) the act of placing a job card somewhere from the accomplishment of being informed by this action. There are two main reasons for this: the act of forming an artefact may be accomplished by a different actor from that being informed by the artefact; the association between the act of manipulating some artefact and the act of being informed by it is an arbitrary one. A certain artefact may hold significance for one actor but not for another. The same artefact may also inform two different actors differently. What turns the accomplishment of being informed into a nonarbitrary phenomenon for particular actors is the notion of a communicative convention. This seems to us to be at the heart of the enterprise of visual management.

It is perhaps no accident that most of the artefacts considered in this paper, and within the general literature of visual management, are designed to encourage and support group rather than individual work. Visible communication in support of coordinated

activity appears to be particularly important to routine group work. In such circumstances it is not surprising to find the high visibility of such artefacts to multiple actors as critical to their effectiveness (Bateman and Lethbridge 2014). The Kanban card (Hirano 1995) is designed to be visible to all production workers to help coordinate the supply and use of materials. The manual whiteboard within healthcare settings (Lederman and Johnston 2011) is deliberately placed to be visible to all nursing staff. Therefore, such artefacts seem especially good at helping to facilitate team work through the informating capacity of the visible artefact (Zuboff 1985).

Feature 3: the place of artefacts within the wider physical environment

The third feature is that the structure of the physical environment in which such articulation takes place is also important to informing actors. The entire physical environment forms the 'gestalt' within which artefacts perform as active social entities (Preda 1999). From the point of view of visual management, the cardholder and the associated job cards within the clothing repair shop are visual devices. But such devices form part of a wider visual system, which is the entire physical environment within which and upon which actors perform work. In other words, the cardholder is not the only visual device important to the coordination of work in this setting. As part of the wider visual system of the clothing repair shop, there is also clothing hung on hangers and placed on a hook outside one of the changing rooms. The very presence of clothes on these hangers signal to workers an intention – namely, it acts as a *directive* to complete these jobs on the same day they are brought in.

A key advantage of visual management as a philosophy is that it focuses on the physical environment within which actors act. It is also interesting that IT systems are actively discouraged in many aspects of this operational philosophy because such systems are seen to take information behaviour away from its point of use (Galsworth 2005). The design principle of placing the visual device at point of use implies identifying the key user and the key use of such artefacts. This gels with the idea of unpacking the articulation of a particular device in terms of its communicative intentions, but also in terms of its performativity or action-outcomes.

Feature 4: affording situated choice

The fourth feature is that the manipulation of physical and visual artefacts is important to supporting situated choice. Within the ways of organising we have described, choices of appropriate action seem to be made using a logic of appropriateness. This means that responses to situations are accomplished using direct appreciation of patterns in the working environment together with tacit knowledge of appropriate response. Hence, within the ICU unit the nurse can make immediate, situated choices (Suchman 1986) about bed allocation. Within the clothing repair shop actors can make instant choices about which garments to select next, as well as the type of work to be performed and by when. Thus, the structure of the physical environment as well as the structure of informative artefacts enables actors to reproduce the spatial and temporal order of clothing repair.

As mentioned in the first section, visual devices within the philosophy of visual management are particularly associated with the attempt to translate organisational expectations into directly observable, concrete practices. Visual devices are meant to enact 'discipline'. They are meant to influence, direct, limit or guarantee actor behaviour through visual devices (Galsworth 1997). One way of theorising about this so-called 'ladder of control' is through the notion of situated choice. Situated choice is constrained choice. The very makeup of the physical environment, together with tacit knowledge held by actors linking structures to conventions of communication, limits action possibilities for actors. The very effectiveness of the ways of organising work described in this paper, which seem to be representative of those proposed within the visual management literature, relies on the immediacy of action taken by actors. This serves to address issues such as the location and specification deficits discussed in the visual management literature.

However, there are key difficulties with thinking through notions of control in relation to first and second-order affordances. The visual management literature appears to suggest that the level of control can be designed into and is associated purely with the artefact itself. But how does this help us decide upon the appropriate way of typing the cardholder and job card with the clothing repair shop case as a visual device? For instance, in terms of the work of Galsworth (1997), is it a visual indicator, signal, control or guarantee? It seems to us that the type you assign to a particular visual device depends upon the communicative conventions which serve to couple the particular act of articulation of the artefact with particular coordinated actions within work.

Hence, when the shop manager first fills out a job card and places it upon one of the racks on the cardholder, this artefact probably serves in the capacity of a visual indicator. It serves to *assert* that work needs to be performed upon a particular garment as well as the time by which such work needs to be completed. But it does not specify which actor should undertake this work and when. However, when some clothing worker takes a job card from the cardholder and starts work on the garment, the very absence of the card on the cardholder serves as a visual guarantee. The particular garment worker *commits* to this work through such an act of articulation and no other worker is able to work on this garment until the card is returned to the cardholder.

These four elements of a theory of operation explain how these systems accomplish action within particular ways of organising operations practices. The theory is illustrated schematically in Figure 6 (which builds upon Figure 1) to show how the theory of affordances is extended in our work beyond Gibson's idea of directly perceived first-order affordances, to accommodate the concept of second-order affordances. Actors (such as A_1) within a particular way of organising use their effector apparatus to articulate particular physical objects as data structures (such as S_1). In the case of the ICU a particular nurse positions a magnetic token (S_1) next to a bed icon on the whiteboard. This act of articulation serves within some domain of communicative convention to create a message (such as M_1). In the ICU case, M_1 constitutes a directive to admit a patient to the ICU. This message is sensed by the sensory apparatus of some other actor (such as A_2), perhaps remote in time and space. Hence, in the ICU case, another nurse, perhaps working on the next shift, senses this message. This message acts as a cue to certain acts of coordinated performance such

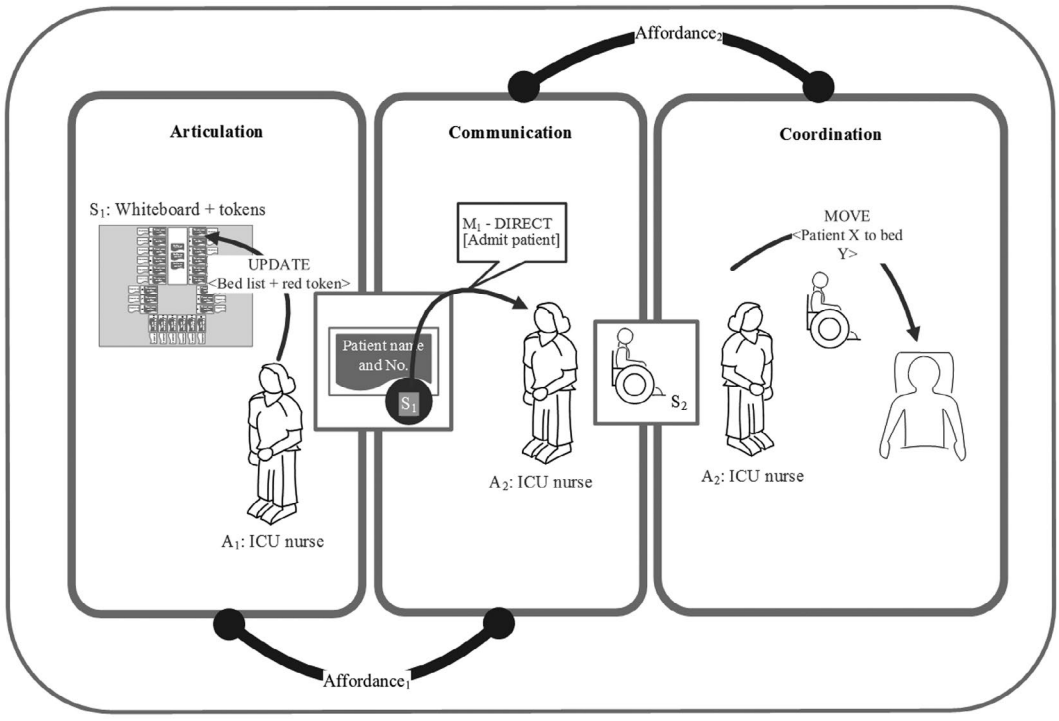

Figure 6. Elements of a tangible information system.

as transforming other structures within the physical environment (such as S_2). S_2 in this case will constitute the physical patient transferred to the ICU, who needs to be allocated to a particular bed within the unit. Within a particular way of organising, the coupling between articulation and communication is realised as a first-order affordance whereas the coupling between communication and coordination is realised as a second-order affordance.

Conclusion

In this paper we identify the systems of visual management as an interesting class of system, but which is little discussed within the academic literature. Not surprisingly, although such systems are ubiquitous in practice they tend to be poorly theorised. We have endeavoured to develop such theorisation as a means to understand and explain why such systems prove successful in practice but also why they endure in the face of computerisation. The theory of affordances offers to us the most productive foundation on which to build such theorisation. However, we observe that to properly understand how visual devices accomplish visual management we need to rework the original theory of affordances in significant ways.

Our contribution is to adapt and extend the theory of affordances to explain how visual management works. The original theory of affordances suggests that objects for action need to be directly perceived. As such, this original theory only explains how the articulation of physical objects affords communication. This connection between articulation and communication we refer to as a first-order affordance. To properly understand the positioning of visual devices within work we need the related notion of a second-order affordance. We propose this idea of second-order affordances to connect communicative action with coordinated work actions.

Within this paper we have highlighted the importance of material and visual artefacts for informative purposes within particular ways of organising the management of operations in manufacturing, software production and healthcare (Scott and Orlikowski 2012). We believe that the enduring use of such physical or tangible artefacts within domains such as production and operations management (Parry and Turner 2006) suggests that they have value as an identifiable class of system for actors that endure in supporting action where digital computing and communication technology is much applied.

Some of the value of the visual devices used within visual management clearly relate to the very simplicity of the technology itself. These include being low cost, easier to use, more robust, more adaptable and generally having a lower environmental impact than digital technologies. However, some of this surface value may certainly be temporal and subject to changes both in adoption and in the skill-sets of users (Vodanovich, Sundaram, and Myers 2010).

Clearly the visual devices described in this paper cannot support all the functionality that an organisation such as a hospital or manufacturing plant might desire from an information system (Setia and Patel 2013). For example, the data manipulated using such artefacts are typically transitory. This makes it difficult to capture such data as a persistent record of work events, to be used for example by the auditing function, as in the case of patient treatments in the healthcare record or stock movements in production settings.

However, in certain situations the artefacts we have described appear to have a deep source of value within ways of organising. This perhaps explains their enduring and continuing use in areas such as lean production management (Murata and Katayama 2010). The high visibility and very physicality of such artefacts appears to make them particularly suitable within informative

environments of situated choice supporting routine work. These material systems are particularly ubiquitous within contemporary production settings. In many instances, the design of this class of system is positively encouraged within many aspects of the practitioner literature as it concerns production and operations management (Grief 1991; Galsworth 1997).

So what does our theorisation offer as a design theory for visual management? In other words, how does it help us do something like the design of a 'visual workplace' in settings such as production or healthcare? What explicit prescriptions fall out of our theorisation in terms of how to develop and implement the visual devices proposed by visual management?

The first key prescription is to think of the devices at the heart of visual management as multimodal. The affordances of such devices have the potential to be perceived by actors in terms of all aspects of an actor's sensory apparatus. In other words, the effectivities of human actors rely upon not only the sensory modality of the visual but also sound, touch, taste and smell. Properties perceived through any sensory modality are nonarbitrary, meaning that such properties are invariant across situations and hence are observer-independent. Affordances have the potential to be perceived directly by actors without any intermediate, conscious, cognitive processing. It is of course no accident, for instance, that much medical machinery used within intensive care use audio signals as situated cues to immediate reaction on the part of nursing staff. There is potential to explore such additional sensory modalities more clearly in the design of the devices of visual management.

The second key prescription involves thinking about 'visual' devices in terms of actors taking action, not as purely physical artefacts. While the material properties of physical artefacts are nonarbitrary, the way in which such structures facilitate action within visual management systems rely upon convention. A way of organising as we have portrayed it is best seen as an ensemble of both humans and artefacts taking action. Hence, 'visual' devices such as manual whiteboards should be understood in terms of not only which actors undertake what articulations with them (first-order affordances) but for what purpose (second-order affordances). In other words, we need to think of such devices not only as physical structures but coupled to the notion of such artefacts as communicative actors (Cooren 2004). For instance, it is evident within Figure 6, that it is the hospital whiteboard (S_1) that is enacting communication to the ICU nurse (A_2), not another human actor.

This leads to the third key prescription, which is to think of physical structures such as whiteboards as performative structures. Such signs or sign-systems are typically introduced into the workplace in an attempt to constrain or enable actors through the opportunities they provide for action. However, introducing a physical object as the 'form' of some sign or sign-system into a workplace, does not guarantee appropriate action in and of itself. To prove effective such form must serve to in-form with the intention to per-form. This means that the designers of artefacts such as whiteboards, magnetic tokens and paper cards need to think through how particular articulations of these data structures relate to particular communicative conventions. Designers also need to think about how particular communicative conventions should couple with specific actions of coordinated work. To design a whiteboard, such as in Figure 6, thought needs to be given not only to the structure of the board itself and how various magnetic tokens are articulated upon it but what the selection and positioning of a particular coloured magnetic token conventionally should communicate and most importantly what coordinated work should result from such communication.

The fourth key prescription arises from both the informative and performative nature of the devices of visual management. That is, to think of visual management in terms of affordances across whole systems situated within the physical environment of a particular work setting, not just in terms of the management of 'visual' devices. We started this paper with a quote from two promoters of visual management, Liff and Posey, who accurately suggest that 'Everything that one can see in an organization sends a message, even a blank wall' (Liff and Posey 2004). Affordance theory suggests that any variation within the physical environment of some work setting can potentially serve to inform and further to perform. Hence, the designer of visual management cannot focus solely upon the device, such as the whiteboard in the case of the ICU. The designer must consider the structure evident in the entire 'gestalt' of the hospital ward.

The fifth and final prescription involves the usefulness of thinking through patterns of action either *as-is* or *as-if* or *to-be*. In other words, we need better ways of thinking through how articulation, communication and coordination occur in existing settings (as-is). We also need ways of thinking through what patterns of articulation, communication and coordination we might want to see happen within some work setting (as-if). Finally, we need better ways of helping to change ways of organising work using 'visual' devices (to-be). In particular, we need ways of communicating the patterns of action expected of particular participating actors in relation to such artefacts within some work setting.

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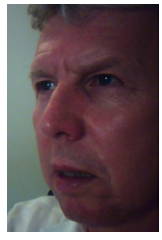
No potential conflict of interest was reported by the authors.

Notes on contributors



Paul Beynon-Davies is currently a Professor of organisational informatics at Cardiff Business School, Cardiff University. Before taking up an academic post, Beynon-Davies worked for several years in the Informatics industry in the UK both in the public and private sectors. Beynon-Davies has engaged in a number of European- and National-funded projects investigating the impact of ICT in both the private and public sector. He has published widely having 15 books and over 90 peer-reviewed academic papers to his name, many in leading journals.

Reeva Lederman is an associate professor in the Computing and Information Systems department at the University of Melbourne. She leads the Computational Bioinformatics and Health Information Systems Research group in CIS. Her research includes foundational work in Information Systems theory as well as applied work in IS design. The latter includes projects such as approaches to using Information Systems to alleviate chronic diseases such as Diabetes and online support systems for young

people suffering from mental health issues. She has been published in EJIS and ToCHI and was the 2012 recipient of the prestigious international Stafford Beer Medal for IS research.

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